INTRODUCTION

Scientists and engineers investigate science phenomena in specific ways, referred to in *A Framework for K–12 Science Education* and the *Next Generation Science Standards* as science and engineering practices. In the classroom, these practices are often visible as students conduct investigations, obtain information, and develop scientific models. Less visible are the cognitive processes students use to connect science knowledge to the world around them. What cognitive tools are they using to think about phenomena? What lenses do they look through? These often invisible, analytical connective frameworks are called crosscutting concepts.

These concepts help provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world.

Although crosscutting concepts are fundamental to an understanding of science and engineering, students have often been expected to build such knowledge without any explicit instructional support. … Explicit reference to the concepts, as well as their emergence in multiple disciplinary contexts, can help students develop a cumulative, coherent, and usable understanding of science and engineering (*A Framework for K–12 Science Education*, 2012, page 83).
Crosscutting Concepts

Crosscutting concepts serve as a bridge—spanning life, earth and space, and physical sciences and connecting the disciplinary core ideas of science. They are a common thread from the beginning of the school year to the end. Most importantly, they serve as a bridge between knowledge and experience, one that provides access to a deeper understanding of the world around us.

These are the seven crosscutting concepts as they appear in A Framework for K–12 Science Education (page 84). They are stated in general terms and not specific to Kindergarten capabilities as will be done later in this chapter for each concept.

1. **Patterns.** Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

2. **Cause and effect: Mechanism and explanation.** Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

3. **Scale, proportion, and quantity.** In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.

4. **Systems and system models.** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

5. **Energy and matter: Flows, cycles, and conservation.** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.

6. **Structure and function.** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

7. **Stability and change.** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.
Next Generation Science Standards (appendix G) identifies several guiding principles for using crosscutting concepts with students.

- Crosscutting concepts can help students better understand core ideas in science and engineering.
- Crosscutting concepts can help students better understand science and engineering practices.
- Repetition in different contexts will be necessary to build familiarity.
- Crosscutting concepts should grow in complexity and sophistication across the grades.
- Crosscutting concepts can provide a common vocabulary for science and engineering.
- Crosscutting concepts should not be assessed separately from practices or core ideas.
- Performance expectations focus on some but not all capabilities associated with a crosscutting concept.
- Crosscutting concepts are for all students.

These guiding principles demonstrate that crosscutting concepts are a vital part of classroom instruction.

Crosscutting Concepts in FOSS Investigations

Crosscutting concepts should be explicitly taught to students. They need to exercise them with guidance and feedback. Initially, students at the elementary level will not know when or how to think about crosscutting concepts. You will need to identify which crosscutting concepts are most helpful for students and to plan instructional strategies and questions that will support and guide students. Most lessons, whether they are one session or several, incorporate a crosscutting concept. Students can often use crosscutting concepts during a sense-making discussion as a lens to process and think more deeply about their experiences and the science ideas they are working on.

In the FOSS Investigations Guide, opportunities to introduce and exercise crosscutting concepts appear in a green call-out in the sidebar next to the steps that implement them. The table “Crosscutting Concepts Opportunities in FOSS” at the end of this chapter is the complete list.

The following pages describe crosscutting concepts and kindergarten student capabilities when using them. These capabilities suggest how to introduce a crosscutting concept, and strategies and questions that can be used in sense-making discussions.
For kindergarten, we recommend focusing on the crosscutting concepts of patterns, cause and effect, and systems and system models, as those provide a sound foundation for students, and are also incorporated into the NGSS Performance Expectations at this grade level. The remaining crosscutting concepts can and should be exercised in kindergarten as well, but they are emphasized in other grade levels.

In the Wrap-Up for each investigation, the review of the phenomena through the focus and guiding questions should also involve discussion about the crosscutting concepts that were useful in thinking about the phenomena. In the Wrap-Up section of the FOSS Investigations Guide, developers have summarized the core ideas that students experience in the investigation and the relevant crosscutting concepts associated with each idea. In later grades, students will generate those crosscutting concepts as part of the review.

The FOSS developers have selected a few of these crosscutting concept opportunities in investigations in each module and given them special emphasis in the Investigations Guide with a green call-out plus a crosscutting-concept icon and a narrative note (as shown in the sidebar to the left). These Grade-Level Examples, shown in the table below for grade three and discussed in this chapter, can bridge between FOSS modules (instructional segments).

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Grade-level examples for crosscutting concepts described in this chapter.

The crosscutting-concept dimension of the NGSS will take time to integrate into your practice. Students will progress incrementally. They will start learning the crosscutting concepts with explicit support. Then they will use their knowledge of crosscutting concepts as tools to think about the disciplinary core ideas they are working on. They will use the crosscutting concepts to understand the connections and interactions between the disciplinary core ideas. In the end, they will be able to make sense of their environment and natural systems, using their knowledge of the crosscutting concepts lens for intellectual integration. But it won’t happen in a lesson or a year; it will grow and develop over years as students engage more deeply with their science studies.
WORKING CROSSCUTTING CONCEPTS INTO INSTRUCTION

Patterns
Recognizing patterns starts at a very early age, even before children can formulate words to describe them. Children test and retest those patterns to verify their observations—rolling balls, pressing buttons to activate electronic devices, and playing peek-a-boo. They are curious, and sometimes upset, when patterns change. These experiences lay the groundwork for scientific study as children enter school and are introduced to patterns in the natural world.

Patterns exist everywhere—in regularly occurring shapes or structures and in repeating events and relationships…. Noticing patterns is often a first step to organizing and asking scientific questions about why and how the patterns occur.

One major use of pattern recognition is in classification, which depends on careful observation of similarities and differences (A Framework for K–12 Science Education, 2012, page 85).

Capabilities of students. In grades K–2, children recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence (Next Generation Science Standards, Appendix G, 2013, page 82).

Introducing patterns. When introducing the crosscutting concept of patterns, have students work with materials and carefully make observations firsthand. When students have had ample time to explore the pattern, gather students for a discussion.

Ask a guiding question so students focus on the target concept, pattern. This may require some probing questions, such as

➤ Was there something that was the same for all the objects? Did they all have the same texture? Color? Shape?

For mathematical patterns, the data should be organized and displayed in tables or graphs so that students can recognize the pattern. These questions can guide students to understand the meaning of pattern, as well as to recognize the pattern in the data.

➤ What do you see? Do the numbers increase or decrease?

Once students have reported their observations and described the pattern, define and reinforce the word pattern.
Patterns in science help scientists study the world around them. Scientists look for things that repeat, increase, or decrease. They look for things or characteristics that are different or the same about what they are studying. <Repeat the pattern students reported.> This is a pattern that you observed.

If you have explored mathematical patterns, point out the connection to those and ask students to identify the patterns.

*In math, what patterns have we observed? In science, when we make observations, we always look for patterns. We can ask questions about patterns. We can try to figure out why those patterns happen, and we can use patterns to help explain what (the phenomena) we are studying.*

**General strategies for patterns.**

- Start with focusing students on two objects, such as two leaves. Ask them to compare the two. Add a third, what is the same or different with all three of these. If students determine the objects all have a particular property or characteristic, provide a nonexample and ask students if it fits the pattern.

- Use a graphic organizer as a class to identify and record similarities and differences to explore a pattern. (See the example from the *Animals Two by Two Module* on the next page.)

- Once students are able to determine a pattern, ask students to develop a ‘rule’ about the pattern of the objects. A statement of a rule is akin to a claim. Provide additional examples and nonexamples for students to sort into ones that fit the pattern and ones that do not.

**Sentence frames for patterns.**

- I notice that _______ is the same for these objects.
- I notice that _______ is different for these objects.
- I wonder if _______ fits the pattern.
- This pattern is similar to _______.

**Taking it further.**

- Create an ongoing lists of patterns. Have students generate the headers for these lists, such as, *Natural* (all leaves have _______) or *Tested* (objects roll faster when you push them harder).

- Discuss why scientists and engineers look for patterns. Ask students how patterns, such as leaf shapes, help them understand more about the system or phenomenon.
**Grade-level examples.** In the Trees and Weather Module, Investigation 2, Part 2, students compare leaf silhouettes. The teacher introduces three different leaf shapes on a felt board. Other leaf silhouettes are introduced one at a time. With each new leaf, students are asked if the new leaf is the same as any of the leaves on the board. If so, they place the similar leaf on top of the one it matches. Students can discuss what is the same about both leaves. When they identify the shape is the same, confirm the pattern. Some leaves have the same shape even though they are from different trees. Students are given shapes that can be used to describe that pattern, such as oval-shaped. Oval-shaped leaves is a pattern. Students are asked to sort real leaves into the shape patterns they identified. As more and more leaves are found, students can identify them by their shape pattern.

In the Materials and Motion Module, Investigation 1, Part 2, students drop water on different kinds of wood. They discover water is absorbed, beads up, or spreads out on different types of wood. They go outdoors and observe drops on different wood. Students can be asked if they notice if there is something the same about the surface of the wood where water beads up. Water beads up or spreads out on wood that is smooth and is absorbed by wood that is bumpy are typical patterns that students identify.

**Connections between modules.** In this section, some of the connections between modules are shared. The purpose of sharing these connections is for teachers to bridge investigations and modules using a particular crosscutting concept. Once students have started using one crosscutting concept, such as patterns, in one context, connections can be made to that experience the next times students experience patterns. As students’ use of patterns increases, see if they can identify opportunities to look for patterns or even look for them without being asked to do so.

In the Trees and Weather Module, students observe the weather in the schoolyard. They are asked to use their senses to observe the areas in sunlight and those in the shade. During the sense-making discussion, students consider if the temperature in the sunlight is warmer, cooler, or the same as in the shade. Students identify, generally, the pattern that the temperature in the sunlight is warmer than in the shade. In the Materials and Motion Module, students sort paper into two piles, those easy to fold and those difficult to fold. They look at the properties of the types of paper and determine the pattern that thin paper is easier to fold than thicker paper. In the Animals Two by Two Module, students compare two types of worms and look for structures and behaviors both worms have in common.
In these three examples, students are working with patterns. Regardless of which module is taught first, the other experiences can be connected back to it. For example, if students have worked with patterns in the **Materials and Motion Module** and are working in the **Animals Two by Two Module**, make a connection between the pattern of the common property folding paper (thin paper) and the common structure of worms (head end and tail end). Questions such as, “We noticed a pattern that all the folding paper was thin, is there anything the worms have that is the same? Is there a pattern about worms? If we found another worm, do you think it would also have a head end and tail end? Why are patterns helpful in science?”

**NOTE**
Additional connections between modules are displayed in the “Crosscutting Concepts Opportunities in FOSS” table for grade K at the end of this chapter.
Cause and Effect: Mechanism and Explanation

When students recognize patterns in phenomena, they begin to ask questions related to those patterns. What causes the ball to always roll down the hill? Why does the Sun come up over that hill every morning? Why do the leaves fall off some trees in the fall but not others? In science, students often observe the effect and then try to determine the cause, like a mystery novel. In engineering, students may try to achieve a specific effect, manipulating the system to uncover how to cause that effect.

Many of the most compelling and productive questions in science are about why or how something happens…. Repeating patterns in nature, or events that occur together with regularity, are clues that scientists can use to start exploring causal, or cause-and-effect, relationships, which pervade all the disciplines of science and at all scales. For example, researchers investigate cause-and-effect mechanisms in the motion of a single object, specific chemical reactions, populations changes in an ecosystem or a society, and the development of holes in the polar ozone layers. (A Framework for K–12 Science Education, 2012, page 87)

Capabilities of students. In grades K–2, students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes. (Next Generation Science Standards, Appendix G, 2013, page 83)

Introducing cause and effect. The introduction of cause and effect often begins with the effect; students make observations or recognize a pattern, and then ask “How did that happen?” or “Why did that happen?” They are thinking about what caused the observable effects. Those questions can often be rephrased to focus students on the relationship.

Here is an introduction to cause and effect, using a student’s observation.

[Student’s name] said, “The ball rolls very far sometimes. Sometimes it goes only a short distance.” You observed that happen. In science, we call those effects. A ball rolling far is one effect. We can think about what caused the ball to roll far. When we figure out what made the ball roll far (effect), we know the cause.

What causes the ball to roll far?

General strategies for cause and effect.

• Have students identify cause and effects in their everyday life. For example, When I drop a can of soda (cause), the soda sprays out when I open it (effect).
• Start an Effect and Cause and a Cause and Effect poster. Often in science students identify an effect (an outcome of an investigation) first and then try to determine the cause, such as some isopods are faster than others. Other times, students manipulate the cause and observe the effect, such as what happens (the effect) when I increase the number of paper clips on a raft.

**Sentence frames for cause and effect.**

• When I <cause>, I notice <effect>.
• If I want <effect>, I need to <cause>.
• I wonder what the effect would be if ______ .
• I think ______ is causing ______ .

**Taking it further.**

• Have students discuss how they could test if an effect (observation) is the result of (caused by) a certain action. Guide them through the process of experimental design to test their predictions.

• Discuss why scientists and engineers look for cause-and-effect relationships. Ask students how the cause-and-effect relationship helped them understand more about a phenomenon, such as a how knowing a ball goes faster when you push it harder.

**Grade-level examples.** In the Materials and Motion Module, Investigation 1, Part 4, students investigate how to change the shape of wood. They describe the simple cause-and-effect relationship that when they rub the wood with sandpaper, the shape of the wood can be changed and sawdust is made. Students sand sticks and observe the effect. This is a good opportunity to introduce the sentence frame “When I <cause>, I notice <observed effect>. This serves as a claim that students can support with data.

In the Animals Two by Two Module, students observe the snails. During the observations, students interact with the snail and observe the effects. They place the snail inside a cup, turn the cup upside down, and pick up the snail by the shell (causes). The observe what the snail does during these interactions (effect). Questions can be asked to have students communicate the cause-and-effect relationships. To take the crosscutting concept a bit further, students can ask cause-and-effect questions, such as “What would happen if we _____?” that could be tested.
Connections between modules. In the Trees and Weather Module, students observe the effects of winter on trees. In the Materials and Motion Module, students examine the cause-and-effect relationships of water on different types of fabric. In the Animals Two by Two Module, students examine the water in the goldfish aquarium. They think about what causes the water to be dirty.

When beginning to look at cause-and-effect relationships in a second module, make connections to those relationships established in the first. For example, when looking at the cause-and-effect relationships for water on different fabrics, ask students to recall the relationships from the Trees and Weather Module. How could they use what they learned about the effects of fall on trees to find out more about fabric? When they looked at the trees in winter, they had to compare the fall trees to the winter trees. To see what water does to fabric, they have to observe the fabric closely before and after adding water.
Scale, Proportion, and Quantity

In science, quantifying is crucial for observation and understanding of quantity and scale. Length, mass, time, temperature, force, and other measurements have magnitude and require units. In kindergarten, using comparing words, such as faster and slower, are a first step towards understanding scale, proportion, and quantity.

In thinking scientifically about systems and processes, it is essential to recognize that they vary in size (e.g., cells, whales, galaxies), in time span (e.g., nanoseconds, hours, millennia), in the amount of energy flowing through them (e.g., lightbulbs, power grids, the Sun), and in the relationships between the scales of these different quantities. The understanding of relative magnitude is only a starting point (A Framework for K–12 Science Education, 2012, page 89).

Capabilities of students. In grades K–2, students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length. (Next Generation Science Standards, Appendix G, 2013, page 84).

Introducing scale, proportion, and quantity. In grades K–2, as students are making observations, they often start with comparative words, such as more, bigger, hotter, and faster. When these words are used, you can introduce scale. For example, when students describe that one ball traveled farther, you might say,

Many of you observed that the blue ball went farther than the red ball. Scientists compare how objects like balls move. They might say one ball traveled farther than another ball. They also use words like faster and slower to compare how balls move. How do you know if one ball went farther than another ball?

General strategies for scale, proportion, and quantity.

• Start with focusing students on observations in which they make comparisons. For example, if they are observing the height of trees, they could identify the trees from shortest to tallest. As they make additional observations, such as circumference, those can be added to their observations.

• Start a list of comparing words students use when they describe objects or organisms. When students record observations in their notebooks, remind them of comparing words they can use.

• Help students improve their drawings by having them critique illustrations you make, such as a tree being the same height as an apple. Introduce conventions about recording observations of
different sized objects. When drawing very small objects, students might draw their observations as if they were looking through a hand lens.

**Sentence frames for scale, proportion, and quantity.**

- This <object> is <comparing word> than this <object>.
- If I compare the (size, speed, temperature, etc.), the ______.
- The amount of ______ is ______ than the amount of ______.

**Taking it further.**

- Ask students to find objects that are taller, shorter, heavier, lighter, etc. than an object they are observing. For example, when they are observing a snail, ask them to find a snail that is faster or slower.
- Discuss why scale is important for scientists and engineers. For example, when scientist study trees, if they know a tree is getting taller, it is growing.

**Connections between modules.** In the Trees and Weather Module, students are asked to find a leaf that is longer than the leaf on a provided card. In the Materials and Motion Module, students compare the speed of the ball when released from different parts of a ramp. Throughout all three modules, students are making comparisons between objects and observed events. As opportunities to make comparisons present themselves, make connections to the words scientists use in all disciplines of science.
Systems and System Models

By the time students enter school, they have experienced countless systems—phones, cars, toys, and the various ecosystems (urban park, seashore, woods). The parts of a system and how that system works can be considered starting in kindergarten.

To do this, scientists and engineers imagine an artificial boundary between the system in question and everything else. They then examine the system in detail while treating the effects of things outside the boundary as either forces acting on the system or flows of matter and energy across it. Yet the properties and behavior of the whole system can be very different from those of any of its parts, and large systems may have emergent properties, such as the shape of a tree, that cannot be predicted in detail from knowledge about the components and their interactions (A Framework for K–12 Science Education, 2012, page 92).

Capabilities of students. In grades K–2, students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together. (Next Generation Science Standards, Appendix G, 2013, page 85).

Introducing systems and system models. Start with a visible system students have worked with, such as a tree. Draw an example on chart paper. Ask students to identify the parts they see and label the drawings. Introduce system.

A system is made up of parts that work together or interact, like this tree system. Scientists study systems to find out how they work and what happens (effects) when something in the system changes (causes). Let’s think about how the parts of our system work together or interact.

Identify a particularly important part (component or structure are also acceptable words to use) of the system. Ask students to identify how that part works with or interacts with other parts of the system. Ask,

What do the roots do for the tree?

Continue asking students to identify the various parts of the tree. Ask students what might happen if the tree didn’t have any roots. Identify that all the parts of the tree work together to help the tree live.

General strategies for systems and system models.

• Start with focusing students on a scientific illustration of a system and identifying the parts. Have students share their observations during a discussion. Draw the system they are studying in the class notebook. Hand a student a word card identifying one of the parts of the system and have them tape the word card next to the corresponding part in the drawing. Repeat this with the remaining parts of the system.
• Make a poster with different systems they have studied in earth, physical, and life science.
• Discuss with students what might happen to the system if a particular part is removed, such as the tail of a goldfish.

**Sentence frames for systems and system models.**

• The parts of the system are ______ .
• <One part> works with <second part> by ______ .

**Taking it further.**

• Do a think aloud to model how to identify more complex systems. Begin at the bottom of the system and identify the parts as you move up the system rather than going in a random order. Another technique is to work from the largest part of the system towards the smallest.

• Provide a drawing starter in the class notebook by drawing the largest part of the system, such as the trunk of a tree. Have several students add additional parts of the system to the drawing.

• Discuss why scientists and engineers study systems. Ask students how focusing on a system helps them understand more about the object or organism.

**Connections between the modules.** In the *Trees and Weather Module*, Investigation 3, Part 2, students are introduced to a thermometer to measure temperature. Several parts are identified, the base, the stem with the red line, and the numbers. Students focus their attention on the red line changes. When the temperature increases, the red line moves up. In the *Materials and Motion Module*, students observe how air makes a balloon rocket move down a line. Students identify the various parts of the system—the balloon, bag, straw, fishing line, tape, chairs. In the *Animal Two by Two Module*, students identify the parts of a terrarium system. Students need to consider how much water and food to provide in the system for the plants and animals to live. As students work with their first system, establish the meaning of a system and a process of representing the system using drawings and labels of the parts. In the second system, have students revisit their notebook entry for the first system. Have students discuss how they described the first system and how they can use that to describe the second system. When making connections between specific systems, focus on how the parts interact with each other, such as, which parts hold the system together, which enable movement, etc.
Energy and Matter: Flows, Cycles, and Conservation

Matter is all around us. Solids, liquids, and gases make up the world we live in and interact with. Students’ thinking might initially be limited to identifying the states of matter, not the flow of matter within and through systems. Energy, also within and flowing through systems, makes things happen. Younger students begin to consider the matter of objects they directly experience.

The crosscutting concept of energy and matter is connected to the disciplinary core ideas addressing energy and matter. While the core ideas are focused on building student understanding of the structure and function of matter, energy, and their interactions, the crosscutting concepts focus more on the effects (matter and energy) and conservation (matter only at the elementary level).

One of the great achievements of science is the recognition that, in any system, certain conserved quantities can change only through transfers into or out of the system. Such laws of conservation provide limits on what can occur in a system, whether human built or natural.... The supply of energy and of each needed chemical element restricts a system's operation—for example, without inputs of energy (sunlight) and matter (carbon dioxide and water), a plant cannot grow. Hence, it is very informative to track the transfers of matter and energy within, into, or out of any system under study.

...Young children are likely to have difficulty studying the concept of energy in depth—everyday language surrounding energy contains many shortcuts that lead to misunderstandings. For this reason, the concept is not developed at all in K–2 and only very generally in grades 3–5. Instead, the elementary grades focus on recognition of conservation of matter and of the flow of matter into, out of, and within systems under study (A Framework for K–12 Science Education, 2012, pages 94–96).

Capabilities of students. In grades K–2, students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes. (Next Generation Science Standards, Appendix G, 2013, page 86).

Introducing energy and matter. Start with an object students have worked with where the object can be broken into smaller piece, such as a piece of wood or craft stick. After deconstructing (sanding) the wood, draw the original piece of wood in the class notebook. Ask students to identify the object they see and have a student draw the wood after sanding. This should include a smaller piece of wood and sawdust. Introduce matter.

When scientists call objects like wood, matter. Everything you see in this room is made of matter. There are different types of matter you will learn about as you get older. The matter we started with was a piece
of wood. When we sanded the wood, the big piece of wood became smaller and we made sawdust. Sawdust is tiny pieces of wood. The wood is still there, it just looks different now. Scientists study what happens to matter when they do things to it, like sand it.

In kindergarten, focus on objects that can be broken up into smaller pieces or are made of smaller pieces. In later grades, students will consider how matter moves in greater depth.

**General strategies for energy and matter.**

- Asking questions to focus students’ attention on what the object (matter) looks like at a particular time can aid in developing this concept. For example,

  ▶ *What does the piece of wood look like at the start? What happens to the object next? What does the object look like at the end?*

- Visually represent the changes to the object energy using arrows or a series of drawings.

- Provide a series of images that show an object changing in an incorrect order, have students identify the correct order.

**Sentence frames for energy and matter.**

- The object starts ______. Next, the object ______.

- The object changes when ______.

- To change the object, I ______.

**Taking it further.**

- Discuss why scientists and engineers study how an object changes.

**Example of energy and matter.** In the Materials and Motion Module, students work with wood, paper, and fabric. Students change these objects by sanding them, putting them together, and taking them apart. The idea of objects being broken into smaller pieces and smaller pieces can make larger objects serve as a foundation for work in later grades.
Structure and Function

Students observe many different structures—the school playground equipment, buildings, and furniture. They readily accept these designed systems as structures. The leg of a beetle, the mouth of a river, and even the hair on your head are also structures; they can be viewed as components, parts, or subsystems that can be broken up into even more subsystems, depending on the scale used for analysis. Both designed and natural structures perform functions. These functions depend on the properties of the objects.

Herein lies a vocabulary challenge. *Structure* has multiple meanings. *Structure* can refer to a system or object, such as a building or leg of a beetle. Structure can also refer to the form or arrangement of the parts of a system and their properties. The shape and stability of structures of natural and designed objects are related to their function(s).

*The functioning of natural and built systems alike depends on the shapes and relationships of certain key parts as well as on the properties of the materials from which they are made.*

Understanding how a bicycle works is best addressed by examining the structures and their functions at the scale of, say, the frame, wheels, and pedals. However, building a lighter bicycle may require knowledge of the properties (such as rigidity and hardness) of the materials needed for specific parts of the bicycle. In that way, the builder can seek less dense materials with appropriate properties; this pursuit may lead in turn to an examination of the atomic-scale structure of candidate materials. As a result, new parts with the desired properties, possibly made of new materials, can be designed and fabricated (A Framework for K–12 Science Education, 2012, pages 96–97).

**Capabilities of students.** In grades K–2, students observe the shape and stability of structures of natural and designed objects are related to their function(s) (Next Generation Science Standards, Appendix G, 2013, page 87).

**Introducing structure and function to students.** When students are looking at a particular object or organism, call for attention. Say,

> You have been observing a goldfish. I want you to look at the tail. Scientists call the parts of objects and organisms, like the tail, structures. Structures have properties.

Have students look at the structure they are studying. Ask,

> What do you notice about the tail of the goldfish? What shape is it? Why do you think the tail is that shape?

When scientists and engineers look at structures, they often try to figure out what the structure is doing. You might think of it as they are trying...
to figure out the job of the structure. That is called the function. The function is what the structure does in a system. The structure is the tail, the function is to help the fish move.

**General strategies for structure and function.**

- Start with some examples of functions of common objects in the classroom. For example,
  - **What are the structures or parts of your shoe?**
  - Once students have identified the structure (object or component), ask what one structure does.
  - **What job or function does the shoelace do?**

- Ask students to identify what functions of a designed object, such as a shade structure, are important to make the object work. What shapes or properties do those structures need to have?

**Sentence frames for structure and function.**

- One structure of this object is ______ .
- The shapes I see are ______ .
- The function is ______ .

**Taking it further.**

- Ask students to identify an important structure of what they are observing, such as the layers in plywood. Have them identify the function of the layers. Ask students to consider that would happen if the structure was made out of something different. If the function of the layers in plywood is to make the plywood strong, what would happen if you used paper instead of wood to make the layers?

- As students progress, have them label the structures of an object drawn in the class notebook in one color and use a second color to identify the function of those structures.

**Grade-level example.** In the *Trees and Weather Module*, Investigation 1, Part 1, students observe the structures of a tree. They identify the trunk, branches, leaves, and roots. In kindergarten, the idea of structure and function is strongly connected with systems and system models.

**Connections between modules.** In the *Materials and Motion Matter Module*, students construct a shade structure and can look at the function of parts. In the *Animals Two by Two Module*, students compare the structures of pill bugs and sow bugs.
Stability and Change

Students are very adept at noticing changes that impact their lives. The arrangement of the classroom, the weather, and the water level in the creek near school are all things that can change. However, things or systems that are stable, or unchanging at a certain level are initially uninteresting for students. Picture an outdoor location, a small system consisting of a rock sitting under a tree in the grass. The location and general appearance of the rock is stable. It doesn’t move and still ‘looks like a rock.’ Over the course of a year, the rock’s appearance changes, water might make it look darker, moss may form on the surface. The leaves around the rock move, the grass may wither but the rock remains firmly positioned and generally unchanged. Students can consider what causes some things to change, but others to remain stable.

Stability denotes a condition in which some aspects of a system are unchanging, at least at the scale of observation. Stability means that a small disturbance will fade away—that is, the system will stay in, or return to, the stable condition. Such stability can take different forms, with the simplest being a static equilibrium, such as a ladder leaning on a wall. By contrast, a system with steady inflows and outflows (i.e., constant conditions) is said to be in dynamic equilibrium. For example, a dam may be at a constant level with steady quantities of water coming in and out. . . . A repeating pattern of cyclic change—such as the Moon orbiting Earth—can also be seen as a stable situation, even though it is clearly not static (A Framework for K–12 Science Education, 2012, page 98).

Capabilities of students. In grades K–2, students observe some things stay the same while other things change, and things may change slowly or rapidly (Next Generation Science Standards, Appendix G, 2013, page 88).

Introducing stability and change. For students to consider stability and change, they need to observe changes or lack of changes over time. When you hear “nothing is happening,” “it’s balanced,” or “things are really different than they were yesterday,” gather students for a discussion.

Ask students what they notice. Listen to their responses. Note what they are reporting changed or did not change. If students are reporting only changes, ask if any part is staying the same. Note: For some designed systems, they might report that a part of a shade structure moves when you touch it, but the tower doesn’t fall down.

* When scientists and engineers make observations, they notice when something changes. You observed <reference specific change>.

➤ What are other examples of changes? [Weather, falling leaves, etc.]
Scientists and engineers also notice when nothing seems to change, such as <reference the reported nonchange>. Things that are stable seem not to change. Whether things are stable or stay the same, change slowly or change quickly, scientists are curious about what causes those changes or effects.

**General strategies for stability and change.**

- Create a poster of an event or a phenomenon in which there is an observable change. Have students identify how long the change takes. Does it happen quickly or over a few weeks?
- Discuss with students how they might record changes that happen over time in their notebook.
- A good system for students to study is the physical classroom. What changes happen in the classroom? How often does the change happen? Is there anything in the class that remains the same for the whole year?

**Sentence frames for stability and change.**

- Something that is changing is ______.
- The change happens <length of time>.
- I wonder if the change will ______.
- I think the change might be caused by ______.
- If <specific change> happens, it means ______.

**Taking it further.**

- Discuss why scientists and engineers study how things change or stay the same. Ask students how focusing on a change could help them understand more about the phenomenon.

**Grade-level example.** In the *Trees and Weather Module*, students look at changes in trees over the course of the year. Ask questions that help them to discover the changes. Students might notice the leaves have come completely off, some branches have fallen off or leave scars. Also focus students’ attention to what has remained the same, such as the bark on the tree.

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Crosscutting Concepts—Grade K
## CROSSCUTTING-CONCEPT QUESTIONS

This table contains sample crosscutting-concept questions that can be incorporated into a sense-making discussion for K–8. For questions that connect with science and engineering practices as well, the connection appears in parentheses.

<table>
<thead>
<tr>
<th>Patterns</th>
<th>Cause and effect</th>
<th>Scale, proportion, and quantity</th>
</tr>
</thead>
</table>
| • What patterns do I see when I observe _____?  
• Is there a pattern that repeats in this system? Is there a shape or structure that I keep seeing?  
• What questions do I have about these patterns? (Asking questions)  
• How can I show or represent these patterns in my model? (Developing and using models)  
• What can I do to test these patterns? (Planning and carrying out investigations)  
• How can I record these patterns in my notebook? (Analyzing and interpreting data)  
• What is causing the pattern? What does the pattern tell me about (the system or phenomenon)? (Designing solutions)  
• How can I use these patterns as evidence to support my claims or reasoning about the system or phenomenon? (Engaging in argument from evidence)  
• How is the pattern the same or different than what I read about? How can I describe my pattern to someone else? (Obtaining, evaluating, and communicating information)  
• What did you observe?  
• What do you think caused that to happen? (Analyzing and interpreting data)  
• How would you describe the relationship between the cause and the effect? (Constructing explanations)  
• What can you change about your system to cause <desired effect> to happen? (Designing solutions)  
• What should we measure during our test? (Planning and carrying out investigations)  
• What units should we use? (Planning and carrying out investigations)  
• What do we need to do to make these observations or measurements? (Planning and carrying out investigations)  
• What relationships do you see in the measurements? (Analyzing and interpreting data)  
• How can I use a model to test my design? (Designing solutions) | • What should we measure during our test? (Planning and carrying out investigations)  
• What units should we use? (Planning and carrying out investigations)  
• What relationships do you see in the measurements? (Analyzing and interpreting data)  
• How can I use a model to test my design? (Designing solutions) |

## Crosscutting Concept Questions

<table>
<thead>
<tr>
<th>Systems and system models</th>
<th>Energy and matter</th>
<th>Structure and function</th>
<th>Stability and change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What is the function of the system?</strong></td>
<td><strong>What matter is part of this system?</strong></td>
<td><strong>What particular shapes or structures are observed in this system at this scale?</strong></td>
<td><strong>What changes do I notice? How quickly is the change happening?</strong> (Analyzing and interpreting data)</td>
</tr>
<tr>
<td><strong>What are the parts or components of the system?</strong> (Developing and using models)</td>
<td><strong>What matter comes into the system?</strong></td>
<td><strong>What roles do these structures play in the functioning of the system?</strong> (Developing and using models)</td>
<td><strong>What can I investigate more closely to recognize the cause of a change?</strong> (Planning and carrying out investigations)</td>
</tr>
<tr>
<td><strong>What is the role &lt;job, function&gt; of each part?</strong></td>
<td><strong>What matter moves or changes in the system?</strong></td>
<td><strong>What design features of appearance and structure are important?</strong> (Defining problems)</td>
<td><strong>What changes would cause it to become unstable or to fail?</strong> (Developing and using models)</td>
</tr>
<tr>
<td><strong>How does &lt;one part&gt; work with &lt;another part&gt;?</strong></td>
<td><strong>What matter goes out of the system?</strong></td>
<td><strong>What properties of the components are important for the function of this design?</strong> (Designing solutions)</td>
<td><strong>How can I improve the stability of my design?</strong> (Designing solutions)</td>
</tr>
<tr>
<td><strong>How can we develop a model of this system?</strong></td>
<td><strong>What does energy do in the system?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>What is not part of the system?</strong></td>
<td><strong>How is energy moving in the system?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>What happens to the system when ______ is removed?</strong></td>
<td><strong>How does energy enter the system?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>What system or systems do we need to model in order to explain this phenomenon?</strong> (Developing and using models)</td>
<td><strong>How does energy leave the system?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>What matter flows into, out of, and within the system? What physical and chemical changes occur during this phenomenon?</strong> (Developing and using models)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>What energy transfers occur into, out of, or within the system? What transformations of energy are important to its operation?</strong> (Developing and using models)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>What inputs are needed for the system to function? What are the desired outputs of the system?</strong> (Defining problems)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Crosscutting Concepts—Grade K
# Crosscutting Concepts—Grade K

## CROSSCUTTING CONCEPTS OPPORTUNITIES IN FOSS

This is a complete listing of every instance where a crosscutting concept is called out in the sidebar of the FOSS *Investigations Guide*. The ones in bold are the grade-level examples described in this chapter.

<table>
<thead>
<tr>
<th>Grade K–2 Crosscutting Concept Statements *</th>
<th>Trees and Weather Module</th>
</tr>
</thead>
</table>
| Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. | Inv 1, Part 1, Step 9: Have a sense-making discussion  
Inv 1, Part 3, Step 7: Share notebook entries  
Inv 1, Part 4, Step 1: Discuss tree shapes  
Inv 1, Part 5, Step 5: Have a sense-making discussion  
Inv 1, Part 5, Step 12: Distribute landforms cards  
Inv 1, Part 6, Step 12: Share notebook entries  
Inv 2, Part 1, Step 9: Have a sense-making discussion  
**Inv 2, Part 2, Step 5: Observe other shapes**  
Inv 2, Part 3, Step 5: Distribute reference cards  
Inv 2, Part 4, Step 6: Have sense-making discussions at centers  
Inv 2, Part 5, Step 4: Add descriptions to the pages  
Inv 3, Part 2, Step 9: Have a sense-making discussion  
Inv 3, Part 3, Step 18: Discuss the weather graph  
Inv 4, Part 1, Step 3: Have a sense-making discussion  
Inv 4, Part 4, Step 7: Return to class  
Inv 4, Part 6, Step 7: View the video on sugar maple trees  
Inv 4, Part 6, Step 8: Share notebook entries  
Inv 4, Part 8, Step 4: Make bark rubbings (optional)  
Inv 4, Part 9, Step 7: Share notebook entries  
Inv 4, Part 9, Step 10: View the video |
| Events have causes that generate observable patterns. | Inv 3, Part 2, Step 4: Measure the temperature of water  
Inv 3, Part 2, Step 8: Observe the effect of sunlight  
Inv 3, Part 3, Step 3: Go outdoors  
Inv 4, Part 2, Step 8: Have a sense-making discussion  
Inv 4, Part 7, Step 3: Get ready for the next group |

*From Next Generation Science Standards, Volume 2, Appendixes, pages 92–95*
## Materials and Motion Module

- Inv 1, Part 1, Step 4: Explore wood samples
- Inv 1, Part 2, Step 6: Monitor progress and discussion
- **Inv 1, Part 2, Step 18: Share notebook entries**
- Inv 2, Part 2, Step 15: Sort paper samples
- Inv 2, Part 3, Step 13: Have a sense-making discussion
- Inv 3, Part 2, Step 15: Share notebook entries
- Inv 3, Part 3, Step 11: Share notebook entries
- Inv 4, Part 2, Step 9: Discuss different possibilities
- Inv 4, Part 3, Step 6: Predict the roll path

## Animals Two by Two Module

- Inv 1, Part 4, Step 2: Guide observations and comparisons
- Inv 1, Part 4, Step 9: Discuss the reading
- Inv 1, Part 4, Step 12: Discuss the reading
- Inv 1, Part 4, Step 14: Share notebook entries
- Inv 1, Part 5, Step 16: Discuss bird movement
- Inv 1, Part 5, Step 22: Discuss the reading
- Inv 1, Part 1, Step 11: Have a sense-making discussion
- Inv 1, Part 2, Step 6: Discuss shell organization
- Inv 1, Part 3, Step 19: Discuss the reading
- Inv 3, Part 3, Step 3: Compare worms
- Inv 3, Part 3, Step 11: Share notebook entries
- Inv 4, Part 2, Step 12: Share information about photos
- Inv 4, Part 2, Step 14: Introduce the sorting mat
- Inv 4, Part 2, Step 12: Share information about photos
- Inv 4, Part 3, Step 12: Discuss the reading
- Inv 4, Part 4, Step 14: Discuss the book

## Crosscutting Concepts

- Inv 1, Part 3, Step 8: Ask questions to guide discussion
- **Inv 1, Part 4, Step 12: Share notebook entries**
- Inv 2, Part 3, Step 3: Ask questions to guide observations
- Inv 2, Part 3, Step 13: Have a sense-making discussion
- Inv 2, Part 4, Step 6: Have a sense-making discussion
- Inv 2, Part 5, Step 11: Discuss the dried bowls
- Inv 3, Part 3, Step 6: Test other fabrics
- Inv 3, Part 6, Step 4: Focus question: What happens to water in sunshine and shade?
- Inv 3, Part 6, Step 24: Have a sense-making discussion
- Inv 4, Part 1, Step 8: Have a sense-making discussion
- Inv 4, Part 1, Step 18: Share notebook entries
- Inv 4, Part 2, Step 5: Discuss findings
- Inv 4, Part 2, Step 8: Distribute blocks and resume explorations
- Inv 4, Part 2, Step 9: Discuss different possibilities
- Inv 4, Part 3, Step 6: Predict the roll path
- Inv 4, Part 4, Step 6: Put an object on the flight line
- Inv 1, Part 2, Step 4: Renew the water
- Inv 1, Part 3, Step 2: Put the tunnel in the aquarium
- **Inv 2, Part 3, Step 8: Observe snail activities**
- Inv 3, Part 2, Step 18: Have a sense-making discussion
- Inv 3, Part 3, Step 13: Focus on photographs
- Inv 4, Part 3, Step 7: Discuss the races
### Grade K–2 Crosscutting Concept Statements *

<table>
<thead>
<tr>
<th>Grade K–2 Crosscutting Concept Statements *</th>
<th>Trees and Weather Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple tests can be designed to gather evidence to support or refute student ideas about causes.</td>
<td></td>
</tr>
<tr>
<td>Relative scales allow objects and events to be compared and described (e.g. bigger and smaller, slower and faster).</td>
<td>Inv 2, Part 3, Step 5: Distribute reference cards</td>
</tr>
</tbody>
</table>
Simple tests can be designed to gather evidence to support or refute student ideas about causes.

**Materials and Motion Module**

- Inv 1, Part 3, Step 8: Ask questions to guide discussion
- Inv 1, Part 4, Step 12: Share notebook entries
- Inv 1, Part 5, Step 12: Discuss the wet wood
- Inv 2, Part 3, Step 3: Ask questions to guide observations
- Inv 2, Part 4, Step 6: Have a sense-making discussion
- Inv 2, Part 5, Step 11: Discuss the dried bowls
- Inv 3, Part 3, Step 6: Test other fabrics
- Inv 3, Part 6, Step 4: Focus question: What happens to water in sunshine and shade?
- Inv 3, Part 6, Step 24: Have a sense-making discussion
- Inv 4, Part 1, Step 8: Have a sense-making discussion
- Inv 4, Part 1, Step 18: Share notebook entries
- Inv 4, Part 2, Step 5: Discuss findings
- Inv 4, Part 2, Step 8: Distribute blocks and resume explorations
- Inv 4, Part 2, Step 9: Discuss different possibilities
- Inv 4, Part 3, Step 6: Predict the roll path
- Inv 4, Part 4, Step 6: Put an object on the flight line

**Animals Two by Two Module**

- Inv 1, Part 2, Step 4: Renew the water
- Inv 1, Part 3, Step 2: Put the tunnel in the aquarium
- Inv 2, Part 3, Step 8: Observe snail activities
- Inv 3, Part 2, Step 18: Have a sense-making discussion
- Inv 3, Part 3, Step 13: Focus on photographs
- Inv 4, Part 3, Step 7: Discuss the races
<table>
<thead>
<tr>
<th>Grade K–2 Crosscutting Concept Statements *</th>
<th>Trees and Weather Module</th>
</tr>
</thead>
</table>
| Objects and organisms can be described in terms of their parts. | Inv 1, Part 2, Step 2: Use the tree-part cards at a center  
Inv 1, Part 3, Step 5: Focus question: What shapes are trees?  
Inv 1, Part 4, Step 1: Discuss tree shapes  
Inv 3, Part 2, Step 3: Focus on the red line  
Inv 3, Part 3, Step 8: Provide an engineering challenge |
| Systems in the natural and designed world have parts that work together. | Inv 1, Part 2, Step 2: Use the tree-part cards at a center  
Inv 1, Part 3, Step 5: Focus question: What shapes are trees?  
Inv 1, Part 4, Step 1: Discuss tree shapes  
Inv 3, Part 2, Step 3: Focus on the red line  
Inv 3, Part 3, Step 8: Provide an engineering challenge |
| Objects may break apart into smaller pieces, be put together into larger pieces, or change shape. | Inv 1, Part 4, Step 5: Have a sense-making discussion  
Inv 1, Part 5, Step 8: Have a sense-making discussion  
Inv 1, Part 7, Step 5: Discuss the structure of plywood  
Inv 1, Part 7, Step 8: Have a sense-making discussion |

Systems in the natural and designed world have parts that work together.

Objects may break apart into smaller pieces, be put together into larger pieces, or change shape.
### Crosscutting Concepts Opportunities in FOSS

#### Grade K – 2 Crosscutting Concept

**Inv 1, Part 1, Step 6:** Share notebook entries
**Inv 1, Part 3, Step 4:** Have a sense-making discussion
**Inv 1, Part 5, Step 10:** Discuss bird sightings
**Inv 1, Part 1, Step 6:** Focus question: What are the parts of a water snail?
**Inv 3, Part 1, Step 6:** Guide observations

**Inv 3, Part 2, Step 14:** Observe worm jars as a class
**Inv 4, Part 1, Step 13:** Share notebook entries
**Inv 4, Part 3, Step 6:** Begin the races
**Inv 4, Part 4, Step 6:** Discuss ongoing care
**Inv 4, Part 4, Step 14:** Discuss the book

**Inv 1, Part 1, Step 6:** Share notebook entries
**Inv 1, Part 3, Step 4:** Have a sense-making discussion
**Inv 1, Part 5, Step 10:** Discuss bird sightings
**Inv 1, Part 1, Step 6:** Focus question: What are the parts of a water snail?
**Inv 3, Part 1, Step 6:** Guide observations

**Inv 3, Part 2, Step 14:** Observe worm jars as a class
**Inv 4, Part 1, Step 13:** Share notebook entries
**Inv 4, Part 3, Step 6:** Begin the races
**Inv 4, Part 4, Step 6:** Discuss ongoing care
**Inv 4, Part 4, Step 14:** Discuss the book

**Inv 1, Part 4, Step 5:** Have a sense-making discussion
**Inv 1, Part 5, Step 8:** Have a sense-making discussion
**Inv 1, Part 7, Step 5:** Discuss the structure of plywood

**Inv 1, Part 4, Step 5:** Have a sense-making discussion

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<table>
<thead>
<tr>
<th>Materials and Motion Module</th>
<th>Animals Two by Two Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inv 4, Part 2, Step 8: Distribute blocks and resume explorations</td>
<td>Inv 1, Part 1, Step 6: Share notebook entries</td>
</tr>
<tr>
<td>Inv 4, Part 4, Step 6: Put an object on the flight line</td>
<td>Inv 1, Part 3, Step 4: Have a sense-making discussion</td>
</tr>
<tr>
<td>Inv 1, Part 4, Step 5: Have a sense-making discussion</td>
<td>Inv 1, Part 5, Step 10: Discuss bird sightings</td>
</tr>
<tr>
<td>Inv 1, Part 7, Step 5: Discuss the structure of plywood</td>
<td>Inv 1, Part 1, Step 6: Focus question: What are the parts of a water snail?</td>
</tr>
<tr>
<td>Inv 1, Part 7, Step 8: Have a sense-making discussion</td>
<td>Inv 3, Part 1, Step 6: Guide observations</td>
</tr>
<tr>
<td>Inv 1, Part 4, Step 8: Have a sense-making discussion</td>
<td><strong>Inv 3, Part 2, Step 14:</strong> Observe worm jars as a class</td>
</tr>
<tr>
<td>Inv 1, Part 7, Step 5: Discuss the structure of plywood</td>
<td>Inv 4, Part 1, Step 13: Share notebook entries</td>
</tr>
<tr>
<td>Inv 1, Part 7, Step 8: Have a sense-making discussion</td>
<td>Inv 4, Part 3, Step 6: Begin the races</td>
</tr>
<tr>
<td>Inv 1, Part 4, Step 8: Have a sense-making discussion</td>
<td>Inv 4, Part 4, Step 6: Discuss ongoing care</td>
</tr>
<tr>
<td>Inv 1, Part 7, Step 5: Discuss the structure of plywood</td>
<td>Inv 4, Part 4, Step 14: Discuss the book</td>
</tr>
</tbody>
</table>
### Crosscutting Concepts — Grade K

<table>
<thead>
<tr>
<th>Grade K–2 Crosscutting Concept Statements *</th>
<th>Trees and Weather Module</th>
</tr>
</thead>
</table>
| The shape and stability of structures of natural and designed objects are related to their function(s). | Inv 1, Part 1, Step 6: Observe schoolyard trees  
Inv 2, Part 5, Step 6: Read *Our Very Own Tree* |
| Some things stay the same while other things change. Things change slowly or rapidly. | Inv 4, Part 6, Steps 2–3: Go outdoors  
Inv 4, Part 9, Step 7: Share notebook entries  
Inv 4, Part 9, Step 10: View the video |

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### Materials and Motion Module

- Inv 1, Part 1, Step 22: Extend the reading
- Inv 1, Part 6, Step 8: Shape the sawdust wood
- Inv 1, Part 7, Step 5: Discuss the structure of plywood
- Inv 2, Part 2, Step 7: Have a sense-making discussion
- Inv 2, Part 2, Step 15: Sort paper samples
- Inv 2, Part 4, Step 11: Discuss the dried bowls
- Inv 3, Part 6, Step 24: Have a sense-making discussion
- Inv 1, Part 1, Step 6: Share notebook entries
- Inv 1, Part 2, Step 6: Guide additional observations
- Inv 1, Part 4, Step 2: Guide observations and comparisons
- Inv 1, Part 5, Step 10: Discuss bird sightings
- Inv 1, Part 1, Step 6: Focus question: What are the parts of a water snail?
- Inv 3, Part 1, Step 6: Guide observations
- Inv 3, Part 3, Step 11: Discuss the reading
- Inv 3, Part 3, Step 12: Share information about photos
- Inv 4, Part 2, Step 4: Introduce the sorting mat
- Inv 4, Part 3, Step 7: Discuss the races

### Animals Two by Two Module

- Inv 1, Part 6, Step 8: Shape the sawdust wood
- Inv 1, Part 7, Step 5: Discuss the structure of plywood
- Inv 2, Part 2, Step 7: Have a sense-making discussion
- Inv 2, Part 2, Step 15: Sort paper samples
- Inv 2, Part 4, Step 11: Discuss the dried bowls
- Inv 3, Part 6, Step 24: Have a sense-making discussion
- Inv 1, Part 1, Step 6: Share notebook entries
- Inv 1, Part 2, Step 6: Guide additional observations
- Inv 1, Part 4, Step 2: Guide observations and comparisons
- Inv 1, Part 5, Step 10: Discuss bird sightings
- Inv 1, Part 1, Step 6: Focus question: What are the parts of a water snail?
- Inv 3, Part 1, Step 6: Guide observations
- Inv 3, Part 3, Step 11: Discuss the reading
- Inv 3, Part 3, Step 12: Share information about photos
- Inv 4, Part 2, Step 4: Introduce the sorting mat
- Inv 4, Part 3, Step 7: Discuss the races
REFERENCES


